METHOD AND SYSTEM FOR CALIBRATING MULTIPLE CAMERAS WITH POTENTIALLY NON-OVERLAPPING FIELDS OF VIEW

BACKGROUND OF THE INVENTION

[0001] The present disclosure relates generally a method and system for calibrating cameras. More particularly, the present disclosure relates to a method and system of calibrating cameras not having a common field of view.

[0002] Multiple cameras are calibrated to allow a large space to be observed. Such an area may be a room or a series of connected corridors that are under surveillance for security purposes. These cameras are often connected to several monitors to be viewed by a security professional in a single location.

[0003] Historically, determining the position and orientation of multiple cameras relative to each other has been a difficult and inaccurate procedure. The process required placing an object with known geometry, in a common field of view of two cameras. However, the irregularly shaped object and common field of view, or overlap, constrained the accuracy and limited the breadth of the surveillance system.

[0004] Accordingly, there is a continuing need to calibrate cameras that do not have a common field of view to eliminate one or more of the aforementioned drawbacks and deficiencies of prior calibration surveillance systems and methods.

BRIEF DESCRIPTION OF THE INVENTION

[0005] A camera calibration system providing for a first transmitter for transmitting a first signal; a second transmitter for transmitting a second signal; a second receiver; a third transmitter for transmitting a first plurality of signals, said second receiver and said third transmitter being movable together as a common unit so that said second receiver receives said first signal and said second signal and so that said first plurality of signals are receivable by a first camera to be calibrated. The system also provides

for a processor in electrical communication with said second receiver and the first camera, said processor being capable of receiving a second plurality of signals from the first camera to be calibrated, said second plurality of signals indicative of receipt of said first plurality of signals, said processor capable of generating a third signal indicative of calibration of the first camera and being configured to determine a relative coordinate system of said common unit, said first transmitter and said second transmitter, and the first camera based at least in part on said first signal, said second signal, and said second plurality of signals.

[0006] A method of calibrating cameras including transmitting a first signal from a first position; transmitting a second signal from a second position; positioning a movable unit in a third position so that said movable unit receives said first signal and said second signal when in said third position and so that said movable unit has a location device within a field of view of a first camera to be calibrated. The method further provides for transmitting a first plurality of signals from said location device receivable by the first camera; and transmitting a second plurality of signals to a processor from said first camera. The method further provides for determining a relative coordinate system based in part on said first, second and second plurality of signals; and moving said movable unit to a fourth position such that said movable unit receives each of said first and said second signals and said location device is within a field of view of a second camera to be calibrated.

[0007] A method of calibrating cameras including transmitting a first signal from a first position; transmitting a second signal from a second position; transmitting a first plurality of signals from a movable position within a field of view of a second sensor; and said movable position having a processor and a first sensor in electrical communication with one another. The method also provides that the processor is capable of receiving a second plurality of signals from said second sensor; determining a relative coordinate system based in part on said first signal said second signal, said second plurality of signals; and moving said movable position to a third position in a field of view of a third sensor such that said first sensor receives said first and said second signals.

[0008] The above-described and other features and advantages of the present disclosure will be appreciated and understood by those skilled in the art from the following detailed description, drawings, and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 illustrates an exemplary embodiment of a front view of camera calibration system;

[0010] FIG. 2 is a schematic of a beacon on a flat surface to calibrate the cameras of the calibration system of FIG. 1;

[0011] FIG. 3 is an exemplary embodiment of two hallways having surveillance cameras and the calibration system of FIG. 1;

[0012] FIG. 4 is a schematic of an embodiment of the calibration system in a series of hallways; and

[0013] FIG. 5 is a second embodiment of the calibration system with a security monitor.

DETAILED DESCRIPTION

[0014] Referring now to the drawings and in particular to FIGS. 1 and 2, an exemplary embodiment of a camera calibration system generally referred to by reference numeral 10 is illustrated. System 10 has very few components configured to calibrate multiple cameras that observe flat surface 20. For example, a cart 12 can support a plurality of sensors 14 and a computer 16. Cart 12 can also support at least one rigidly mounted landmark but preferably a plurality of rigidly mounted landmarks 18 is preferred mounted at different heights on cart 12. For purposes of illustration, 2 landmarks 18 are shown. The location of sensor cameras 14 and landmarks 18 are known relative each other on cart 12. Sensors 14 and beacons 22 allow system 10 to

obtain accurate data about the position and orientation of cart 12. System 10 calibrates multiple cameras by establishing relative positions in between these cameras.

[0015] Referring now to FIGS. 1 and 2, cart 12 is positioned on flat surface 20 near a plurality of beacons 22. The position of cart 12 is arbitrary. System 10 uses the position of cart 12 as a mathematical reference from which relative positions of the plurality beacons 22 will be calculated. The plurality of beacons 22 are shown as lights; however, any transmitters capable of producing, for example sound or a magnetic field could be used. Sensor cameras 14 sense beacons 22 positioned on flat surface 20. Sensor cameras 14 are shown; however, any receiver capable of receiving information from a specific transmitter could be used. Sensor cameras 14 and computer 16 are operatively connected to capture data from beacons 22. From these data, computer 16 computes a plurality of positions for beacons 22 on flat surface 20 relative to cart 12 and stores these positions. When beacons 22 are moved, computer re-computes new positions for the beacons 22 on flat surface 20. These positions are stored by computer 16 and must be determined accurately because they will be used to calculate the exact coordinates of cart 12 when it is moved to a new location.

[0016] Referring now to FIG. 3, computer 16 is operatively connected to surveillance cameras 24, 26, and 28 having fields of view 30, 32 and 34, respectively, on flat surface 20. The position of cart 12, thus landmarks 18 is known and stored by computer 16. Fields of view 30 and 32 do not overlap. Cart 12 is in field of view 30 of camera 24. When cart 12 is in position A, computer 16 captures data from surveillance camera 24 and stores positions of landmarks 18. Camera 24 must capture at least eight images of landmarks 18. For example, cart 12 has two landmarks 18. Therefore, cart 12 must be moved at least four times for camera 24 to capture eight images of landmarks 18 in position A. Computer 16 stores images as data for camera 24 for calculations of camera 24 position relative to cameras 26 and 28. Landmarks 18 are shown as lights; however, any transmitters capable of producing for example sound or a magnetic field could be used. In position B, the same process is repeated with respect to camera 28 having field of view 34. In

position B camera 28 must collect at least eight images of landmarks 18 from cart 12. Computer 16 captures data from camera 28 and stores them. Computer 16 can compute a relative position in between cameras 24 and 28. Cart 12 can be moved into field of view 32 of camera 26 to collect eight images of landmarks 18. After capturing data from cameras 24, 26 and 28, computer 16 can calibrate their positions relative to each other over surface 20.

[0017] Referring to FIG. 4, the method of the invention will be explained by way of example. Computer 16 is operatively connected to a plurality of surveillance cameras 36, 38 and 40 and sensor cameras 14. In FIG. 4, there are three locations on flat surface 20, specifically Locations A, B and C. Locations A, B and C, each have a plurality of surveillance cameras 36, 38 and 40, respectively. Initially, cart 12 is in field of view of the plurality of cameras 36 at Location A, although its initial position is arbitrary. Cameras 36 in Location A have overlapping fields of view. Beacons 42 are placed near cart 12 on flat surface 20 in Location A. Sensor cameras 14 capture data from cart 12 and computer 16 computes positions for beacons 42 relative to cart 12. . In Location A, each of the plurality of cameras 36 must capture at least eight images of landmarks 18 to be calibrated relative to cameras 38 and 40. Computer 16 stores these images as data from the plurality of surveillance cameras 36 in Location A and computes their location with respect to cart 12. Beacons 42 are moved multiple times and new positions are continually stored by computer 16. Computer 16 will use beacon positions to calculate an accurate position of cart 12 when it is moved to location B. Beacons 42 can be moved closer to cameras 38 in location B such that they will be in view of sensors 14 when cart 12 is in view of cameras 38.

[0018] Cart 12 can be moved to Location B in field of view of the plurality of surveillance cameras 38. Sensors 14, in Location B, must be capable of observing beacons 42 still in Location A. Computer 16 relates the new position of cart 12 to the known position of beacons 42 using known mathematical principles. Computer 16 can infer the position of cart 12 in location B. Again as in location A, in Location B, each of the plurality of cameras 38 must capture eight images of landmarks 18 that are stored by computer 16 as data for calibration of relative position. A relative position

of cameras 38 can be determined because the position of landmarks 18 on cart 12 are known with respect to beacons 42. Computer 16 is able to relate the position of surveillance cameras in Locations A and B because each camera was referenced to the cart 12 of known position on surface 20.

[0019] In location C, camera sensors 14 of cart 12 must be able to observe beacons 42 in location B. Computer 16 relates the new position of cart 12 to the known position of beacons 42 still in Location B. Computer 16 can infer the position of cart 12 in Location C using known mathematical principles. Surveillance cameras 40 have overlapping fields of view and must capture at least eight images of landmarks 18 from cart 12 of known position. Computer 16 captures these images as data from the plurality of cameras 40 and computes the relative positions of surveillance cameras 40 to cart 12. Computer 16 will also relate the positions of the plurality of surveillance cameras 40, to the relative positions of surveillance cameras 36 and 38 even though they do not have any fields of view in common. Furthermore, error reduction by camera calibration system 10 is achieved by ensuring cart 12 returns to Location A and repeats the process in locations B and C over surface 20.

[0020] A second exemplary embodiment of system 10 is described with reference to FIG. 5. Again system has a plurality of cameras 36, 38 and 40 and computer 16 connectable to a security monitor 48. System 10 also includes a security monitor 42, a synthetic image 44, flat surface 20 and a connection 46 to connect computer 16 to monitor 48. Synthetic image 44 is created using appropriate software resident on computer 16. Synthetic image 44 is a real-time virtual image that can be supplied with actual objects on flat surface 20. Synthetic image 40 does not require overlapping fields of view for its creation. In this embodiment, a security professional can view monitor 48 and observe surface 20 by observing a single synthetic image 44, instead of viewing actual images of surface 20 on multiple monitors.

[0021] System 10 of FIG. 5 can be used for a modeling application. For example, computer 16 could capture data from the plurality of surveillance cameras 36, 38 and

40. An object such as a person could be observed on a flat surface 20. In this application, computer 16 could manipulate such data to generate a three-dimensional rendition of a person's body part. For example, if only a side view of a person's face is visible by a surveillance camera, data representing that face portion could be rotated to complete a three-dimensional model of the face to more easily identify the face.

[0022] While the instant disclosure has been described with reference to one or more exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope thereof. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the disclosure without departing from the scope thereof. Therefore, it is intended that the disclosure not be limited to the particular embodiment(s) disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.